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Let's (NOT) get physical

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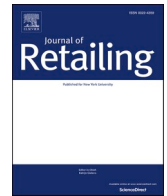




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Let's (NOT) get physical: Cross-format dilution when launching physical counterparts with unique digital assets

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ABSTRACT

As brands seek new revenue streams in the metaverse, selling unique digital assets (UDAs)—like virtual sneakers, artwork, or clothing—represents a promising opportunity. But does offering both digital and physical versions help or hurt in driving favorable consumer responses (e.g. intention to purchase, willingness to pay)? Across six experiments, we find that digital-only UDAs generate stronger purchase interest than those paired with a physical counterpart. This happens because also adding a physical version of the asset reduces the sense that the digital item is truly unique—making it feel less special and less “yours” to the individual. We label this a *cross-format dilution* effect. Nonetheless, brands can choose to sidestep this by limiting access to the physical version (e.g., display-only) or by releasing the digital item before the physical one.

1. Introduction

When Coca-Cola entered the Decentreland metaverse in 2021, they auctioned off a new and exciting range of unique digital assets (UDAs), including a bright-red branded bubble jacket to be worn by avatar personas created by online users within the community. The move signified a big step forward in expanding their product portfolio. But would the asset have been evaluated as more or less desirable had physical versions of the same product existed? That is, if Coca-Cola adopted a dual-format approach, where the asset was available in both the metaverse (digital form), and in the real world (physical form), how would it be evaluated by consumers? In the current research, we address this important strategic question.

In the metaverse, brands and retailers currently trade in *unique digital assets* (herein UDAs) supported by non-fungible tokens (NFTs). These are cryptographic assets underpinned by blockchain algorithms (Hugo, 2021), enabling secure storage and seamless transfer between consumers and platforms (Yoo et al., 2023). Within the metaverse the NFT market is currently valued at approximately USD 22 billion, with growth potential estimated to be around 400 % by the end of 2025 (Katatikarn, 2023). An avenue where blockchain technology is thought to have considerable potential is in the creation of UDAs resembling and extending ownership opportunities currently dominated by physical products (Ali et al., 2023). For instance, limited-edition collectible cards (e.g., National Basketball Association cards) can be produced, stored, and traded safely through the metaverse, whilst virtual malls can be perused for digital items (e.g., apparel and accessories) ready to be worn by avatar personas. As a further illustration of the latter, Dolce and Gabbana created an exclusive NFT collection for Venice Fashion Week in 2021, which sold for nearly USD 5.7 million (Williams, 2021).

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Research endorses a positive sentiment towards different forms of digital possession (Denegri-Knott & Molesworth, 2010; Watkins et al., 2016; Mardon & Belk, 2018), suggesting that UDAs traded in the metaverse deserve to be considered within retailing and marketing strategy (Sundararajan, 2022). As such, we focus our attention on understanding ways in which this potential might be realized by exploring factors that enhance purchase evaluations and uptake. Specifically, we investigate whether the format in which retailers and brands make UDAs available to consumers matters, or not (i.e., UDA format availability). To this end, we explore whether, for the same UDA, deploying a ‘digital-only’ (only available in the metaverse) or ‘dual-format’ (obtainable in the metaverse but with physical versions available for other consumers to buy) influences purchase evaluations towards it.

Whilst a reasonable speculation might be that this *should not* impact how consumers feel about a digital asset in the metaverse, we argue this is far from trivial. Indeed, when a dual-format approach is adopted (e.g., a Gucci handbag available to buy in the metaverse but *also* available for others to purchase in stores), we expect that consumer perceptions of the UDA will diminish. We label this a ‘cross-format dilution effect.’ This, we argue, manifests because physical products are generally valued higher by consumers than digital ones are (Atasoy & Morewedge, 2018), and so, extending the availability of the asset (i.e., the digital Gucci handbag) to a physical form works to reduce feelings of *psychological ownership* towards the UDA (Furby, 1978; Dittmar, 1992; Ringler et al., 2019; Peck & Luangrath, 2023). Specifically, anticipated ownership (prior to purchase) becomes lower as a result of perceiving the UDA to be less unique (i.e., special) since other consumers now have access to buy a more highly valued equivalent (Atasoy & Morewedge, 2018). Nonetheless, and in line with existing research on psychological ownership (Atasoy & Morewedge, 2018), we establish that dilution caused by a dual-format approach can be reduced if consumers are *ineligible* to purchase the physical product (e.g., available only as an exhibit within a retail store), or if the UDA, rather than the physical version, is released to the market first (i.e., ordering).

These predictions are tested across six online experiments with data pertaining to different types of unique digital asset typically bought and sold within the metaverse (e.g., sneakers, handbags, collectible cards, art). The research makes three contributions to extant theory. First, we provide a richer understanding of how users of the metaverse evaluate and make purchase decisions for unique digital assets (Yoo et al., 2023). We study this by looking at the interplay that occurs between digital and physical products of the same type. This addresses the recent call by Yang (2024) which encouraged further work that compares and contrasts how *format availability* can work when physical and digital products are released concurrently.

Second, and in making the contribution above, we introduce the *cross-format dilution effect* as an explanation of what happens to the purchase evaluations of UDAs when physical versions of the asset are also available for other consumers to own. In doing so, we extend the contexts in which *psychological ownership* (feelings of ownership prior to purchase) determines important consumer behaviors (Peck & Shu, 2009; Peck & Luangrath, 2023). Previous research has articulated how psychological ownership is typically higher for physical over digital products, in part, because of the *control* through tactile and tangible attributes it affords (Atasoy & Morewedge, 2018). In an extension of this, we establish an additional threat that physical products pose to digital consumption. In isolation, physical products seem to be valued *more* than digital products but, when considered alongside a digital product, their mere coexistence works to reduce the anticipated psychological ownership that consumers feel towards the digital asset. This dilution is not because the consumers themselves can, for instance, touch and control the physical product (Atasoy & Morewedge, 2018) but as a result of *other consumers* having this opportunity.

Finally, with reference to calls by Yoo et al. (2023) who suggest a need for scholars to establish how retailers and marketers can attract customers to digital assets, we offer some theoretically driven but clear and practical guidelines. When marketing unique digital assets within the metaverse, practitioners must carefully manage (or prepare to manage) the *purchase eligibility* of physical products to other consumers as well as the order in which each component in a dual-format is launched (*order*).

1.1. Theoretical background and hypothesis development

1.1.1. Unique digital assets (UDAs) in the metaverse

The metaverse encompasses 3D virtual, augmented, and mixed realities where individuals can engage in socialization, entertainment, education, work, and other activities (Yang, 2024). Whilst potential applications are wide-ranging, illustrative examples include developing and managing avatars inhabiting virtual worlds, and the use of virtual reality (VR) technology to attend and take part in virtual events. Such activities naturally provide new opportunities for consumption, which scholars predict will disrupt prevailing social norms currently underpinning consumer–firm relationships (Barrera & Shah, 2023; Dwivedi et al., 2023). A prominent reason for this is because the metaverse provides a rich and immersive, virtual environment whereby products can be showcased, and consumers can intimately interact with goods in new and innovative ways (Yang, 2024).

Under the umbrella of digital products, unique digital assets (UDAs) are a type of product (or other form of asset), delivered in a digital format. UDAs are currently traded as non-fungible tokens (NFTs) within the metaverse. Underpinned by blockchain technology, NFTs exist in limited or modest quantities (Hugo, 2021), with four characteristics distinguishing them from physical products. These are: (i) more freedom within the design process to enable smoother logistical aspects such as production and distribution; (ii) unique consumer experiences can be embedded within the underlying technology (as opposed to sensory appeal which is important with physical goods); (iii) immunity from the natural deterioration that physical products inevitably receive over time and, finally; (iv) clearer transparency in provenance and ownership afforded by blockchain (Yang, 2024). Excitingly, and in reference to (ii), by developing and distributing unique digital assets, firms offer consumers a new way to interact with products (Sundararajan, 2022). For instance, UDAs can be seen as particularly meaningful to consumers, especially where there is a pleasure in collecting and owning those items (Griffiths et al., 2024). Given these opportunities it is, perhaps, not surprising that marketers are turning their attention towards this opportunity. However, this poses a crucial question: How can firms configure UDAs to make them more desirable to consumers? Whilst, from a marketing strategy perspective, there is potential for this at different stages of the customer journey

(Colicev, 2023), we focus attention on *format availability*; that is *how* the UDA is made available to consumers (i.e., the format) within, and outside, the metaverse.

1.1.1.1. Format availability. When launching a UDA, we consider two approaches or ‘formats’ that brands and retailers can follow when making it available—(i) as a standalone asset, where the product is *only* available in digital form (we refer to this as a *digital-only* asset) or (ii) as part of a cross-format strategy whereby physical versions of the same product exist beyond the metaverse. We refer to this as *dual-format* availability. Revisiting the Coca-Cola example provided above, if the bubble-jacket is *only* available in the metaverse, it would represent a *digital-only* ‘format availability.’ Should the brand have also chosen to develop physical versions of the same asset and made it available within the *real world* (e.g., via retail stores), it would be deploying a *dual-format availability*. In terms of maximizing value against the sunk cost of product designs, it may be tempting for brands to simply leverage any investment in the UDA by extending the same product with a physical version, or vice versa. After all, similar rationales support why many brands opt for product line and/or brand extensions (Childs et al., 2018). However, is this choice so clear-cut? We argue that *format availability*, in fact, has a significant, and somewhat surprising, effect on consumers’ purchase evaluations for UDAs.

1.1.1.2. Cross-format dilution via psychological ownership. When a UDA is sold as part of a dual-format (versus a digital-only approach), we expect that purchase evaluations, measured in terms of product appraisals such as intent to purchase, reduces. We call this a *cross-format dilution effect*. Dilution has been studied in several important marketing and retail contexts, ranging from brand equity dilution that can occur following certain brand extensions (Gürhan-Canli & Maheswaran, 1998; Ahluwalia & Gürhan-Canli, 2000), to reduced perceptions of brand image when consumers are encouraged to rent rather than own products (Barnes & White, 2024). However, to the best of our knowledge, dilution has not previously been studied as a consequence of the format in which brands (or retailers) make digital assets available to consumers in the metaverse. We suggest that this dilution (in the form of lower product evaluations) happens because the coexistence of a physical version of a UDA, implicit in a dual-format offering, works to lower feelings of (anticipated) *psychological ownership* towards the UDA.

Psychological ownership refers to a personal sense of possession associated with an item or object (Furby, 1978; Dittmar, 1992; Pierce et al., 2001). From a consumerist standpoint, this evaluation is an affective response leading to stronger feelings of attachment to, for instance, products and brands (Shu & Peck, 2011; Dolbec & Chebat, 2013). Whilst originating in psychology (Furby, 1978), there has been a steady rise in marketing studies that measure psychological ownership in applied research (e.g., Peck & Luangrath, 2023). This is perhaps due to its predictive power in driving positive consumer responses, explaining outcomes such as willingness to pay (Fuchs et al., 2010), positive word of mouth (Kirk et al., 2015), and purchase intentions for specific products and services (Spears & Yazdanparast, 2014). Although psychological ownership has predominantly been studied from the perspective of physical products, digital contexts as wide ranging as access-based services (Fritze et al., 2020), music streaming (Sinclair & Tinson, 2017), and management of avatars (Watkins et al., 2016) have also all been shown as capable of generating feelings of ownership and attachment.

According to Peck and Luangrath (2023), four motives drive heightened psychological ownership. These are: home (a desire for grounding in a physical space); need for stimulation (excitement gained from shopping and collecting items); effectance (a desire to exert control over one’s environment); and signaling of self-identity. Whilst we return to effectance shortly, we center our argument around the latter motive. *Signaling of self-identity* explains how consumers feel more connected to products that they can use and are able to signal their identity with. For instance, consumers might develop feelings of ownership to more aesthetically pleasing products, in part because it acts as a signal to others of a passion for beauty in design (Pierce et al., 2003). Signaling in this way allows consumers to differentiate from others, which can be achieved by owning or being associated with something that is considered special, unique, or exclusive (Peck & Luangrath, 2023). Namely, items established to be scarce in supply (e.g., limited-edition ranges, or handmade products) tend to generate higher levels of psychological ownership (Wu & Lee, 2016) because they are seen as more unique and worthy of inducing *pride in ownership* (see Ahuvia et al., 2018).

In continuation of the argument above, we anticipate that, when a UDA is sold in a dual-format strategy, which includes a physical version of the asset being available for other consumers to purchase in the real world, then anticipated psychological ownership (and subsequent purchase evaluation) is negatively impacted (diluted); but why? Research has established that, because physical products are considered as more permanent, tangible, and tactile, they generate more psychological ownership than digital equivalents. Indeed, since physical products engender these qualities to a greater degree, there is a notable preference towards them (Atasoy & Morewedge, 2018). So, when a UDA is also available in a physical form, it works to dilute evaluations of the format uniqueness – that is, a consumer’s subjective evaluation of how distinct, special, exclusive, or one-of-a-kind a product format is in comparison to other available alternatives format. It captures the degree to which a product format stands out from similar offerings, making the product appear rare or notably different in ways meaningful to the consumer.

This happens because *other* consumers can (i) now own a different version of the product and (ii) that version possesses qualities (i.e., permanence, tangibility, tactility) that are typically considered as more valuable (Atasoy & Morewedge, 2018). Taken together, (i) and (ii) weaken appraisals of format uniqueness and pride in ownership associated with purchasing the UDA, softening the signaling ability it affords to the consumer. As such—and in line with the conceptual model displayed in Fig. 1—we propose that a dual-format strategy will yield weaker purchase evaluations (e.g., purchase intention) towards the digital asset. Formally stated, we expect that:

H1. *When a UDA is available as part of a dual-format whereby physical versions of the asset exist, then purchase evaluations towards the UDA will decrease.*

H2. *The reduction in purchase evaluations, as a result of the dual-format, arises as a consequence of lower levels of anticipated psychological*

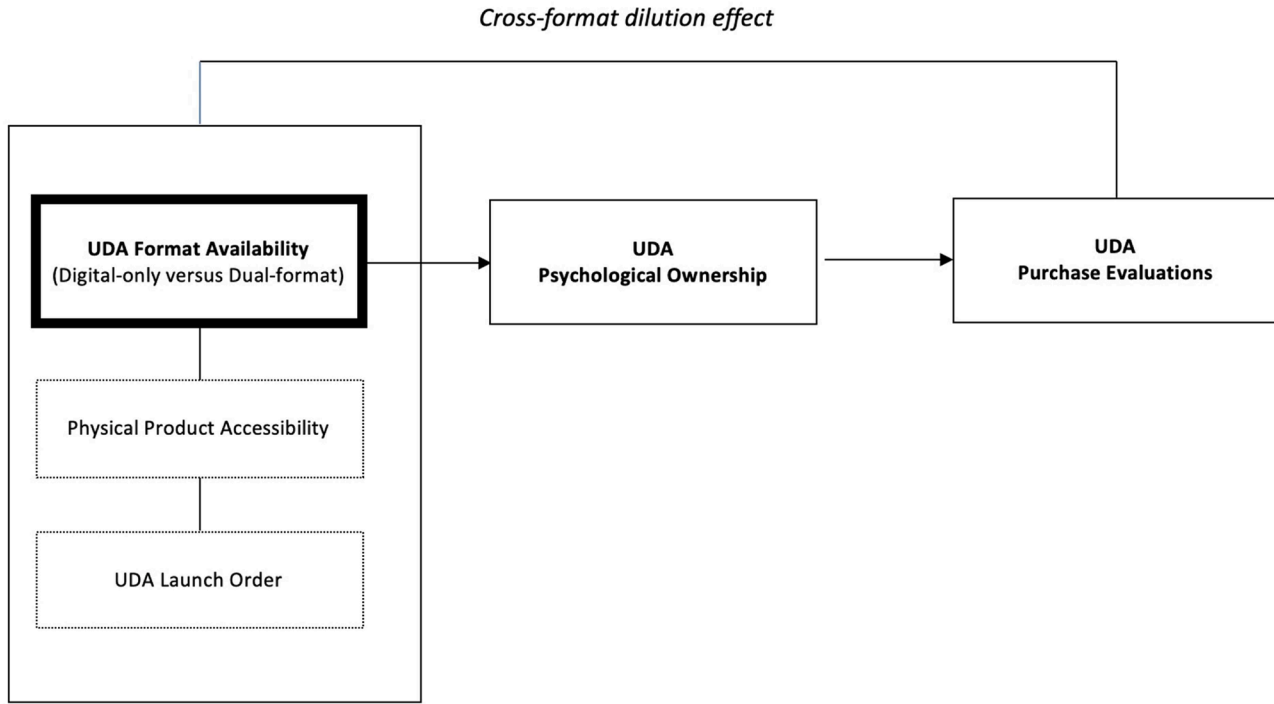


Fig. 1. Conceptual model of the cross-format dilution effect.

ownership towards the UDA (i.e., as a result of the cross-format dilution effect).

1.1.1.3. Potential mitigating effects. We expect that dilution happens when a physical version of the asset is accessible and available to other consumers. However, brands will occasionally develop physical products that are not intended to be purchased, owned, or even used. For example, the luxury car brand McLaren has 22 separate NFTs that, when combined, constitute a digital MCL35M racing car. Whilst this digital asset can be collected by consumers, a physical version (i.e., a McLaren Formula One car) exists but cannot be purchased by enthusiasts—they cannot buy or own it. Indeed, in retailing, physical products are sometimes deployed in ways that resemble museum artifacts within stores, primarily with the goal of capturing attention and interest. For instance, imagine finding a vintage Cristiano Ronaldo shirt in a case, displayed at the official Real Madrid store—there to be viewed but never for sale.

To understand how the mere existence of a physical product might impact one's psychological ownership of a digital one, an understanding of effectance motivation is needed. As a further antecedent of psychological ownership (see Peck & Luangrath, 2023), effectance recognizes that consumers feel more connected to objects that they can exert control and mastery over. As control increases, anticipation of psychological ownership has a chance to develop. This presumes that the object (i.e., product) is manipulable and accessible (Pierce & Peck, 2018). It is worth noting that legal ownership is not a prerequisite for this. For example, people can develop feelings of ownership towards car park spaces or even stools at a public bar (“this is my usual space at the bar!”) but only because previous use has developed in such a way that a level of control over its utility has been established (Peck & Luangrath, 2023). This process related neatly to the idea that different levels of access to physical versions of an asset will shape perceptions of uniqueness and one's identity signaling ability. When others do not have access to a physical counterpart, the digital-only version becomes an even more exclusive marker of identity or status (Han et al., 2010; Aggarwal et al., 2011). We refer to this broad scenario as *eligibility* (eligible versus ineligible). Thus, when a physical product is included in a dual-format strategy, dilution will occur only as a result of others having eligibility to own or use that version of the UDA. We, therefore, expect to see the following:

H3. *When other consumers do not (vs. do) have eligibility to own or use a physical version of a UDA, the cross-format dilution effect will be weakened through psychological ownership. Specifically, reduced physical eligibility will enhance psychological ownership of the UDA, which in turn will lead to higher purchase evaluations.*

Finally, we consider whether the ‘order’ in which a UDA is made available (i.e., launched) as part of a dual-format approach impacts dilution; for instance, does it matter if a UDA is available prior to, or after, the physical version? For some retailers, taking early steps into the metaverse is a cautious venture which lends itself to leveraging existing sunk costs and assets; as many apparel brands have achieved success by creating digital versions of existing physical clothing (Sundararajan, 2022). Similarly, for other brands, the metaverse represents an opportunity to develop native digital products that may later spawn other brand extensions—such as physical versions (Colicev 2022).

Past research has established how consumers naturally tend to elicit preference for those objects, including brands, that they are exposed to first (Niedrich & Swain, 2003, 2008). Known as the ‘primacy effect’ (Dreze et al., 1994), early exposure appears to also translate into higher feelings of psychological ownership (see Morewedge et al., 2021). In parallel with this logic, a plausible explanation once again links to feelings of uniqueness and pride of ownership for the UDA. When a product is released first, it creates lay associations of being *the original*, providing a quasi-halo of distinctiveness against that which then follows (Moldovan et al., 2011). Following this logic, we expect that, when a UDA is released as part of a dual-format that includes a physical product, cross-format dilution lessens when consumers are made aware that the UDA has been released prior to the physical version (i.e., the UDA is the original) and reverses when the UDA is the ‘copy.’ As such:

H4. *Awareness that a UDA was released before (vs. after) its physical counterpart will weaken the cross-format dilution effect through psychological ownership. Specifically, earlier digital release timing will increase psychological ownership of the UDA, which in turn will lead to higher purchase evaluations.*

2. Overview of studies

In Study 1, we establish the role of format availability in driving purchase evaluations (UDA_{digital-only} vs. UDA_{dual-format}), to find out whether the coexistence of a physical version of the UDA works to reduce purchase evaluations (H1). In Study 2A, we examine whether this dilution manifests because the dual-format approach causes lower levels of psychological ownership (the mediator) towards the UDA (H2). Study 2B provides further validation of the model, clarifying that dilution in psychological ownership occurs because the format makes the UDA appear as less unique (and special). Studies 3A and 3B focus on H3 by examining whether purchase eligibility, captured in terms of other consumers being able (eligible or ineligible) to own or use the physical product, plays a mitigating role in the model. Finally, in Study 4, we test whether the *order* in which the UDA is launched matters (H4). Table 1 summarizes the studies.

2.1. Study 1: test of UDA format availability on purchase evaluations

This study tests H1. A scenario-based between-subjects design with two conditions was employed with the UDA made available (format availability) to consumers as part of either a digital-only or a dual-format approach (UDA_{digital-only} vs. UDA_{dual-format}). Given

Table 1
Study summary.

Study	Product	Hyp Tested	Context	Design	Mediator	Dependent Variable(s)	
1	Art (virtual house)	H1	Purchase of a piece of digital art for their virtual home. Two conditions: digital-only available only as a UDA, and dual-format whereby a physical version of the UDA is also available for other consumers to own in the real world	Two-factor between-subjects (digital-only vs. dual-format)	N/A	Purchase Intent	Willingness to Pay
2A	Apparel (avatar)	H2	Purchase a pair of digital sneakers for their avatar. Two conditions: digital-only and dual-format availability	Two-factor between-subjects (digital-only [50 pairs] vs. dual-format [25+25 pairs])	Psychological Ownership	Purchase Intent	
2B	Apparel (avatar)	H2	Same as Study 2A—with amended number of copies	Two-factor between-subjects (digital-only [25 pairs] vs. dual-format [25+25 pairs])	Psychological Ownership	Purchase Intent	
3A	Apparel (avatar)	H3	Purchase a baseball cap for their avatar available in two main conditions: dual-format where other consumers could buy the physical version in real life (dual-format eligible) and where they were unable to do so (dual-format ineligible). A digital-only condition included for reference	Three-factor between-subjects dual-format purchase eligible vs. dual-format purchase ineligible (vs. digital-only reference)	Psychological Ownership	Purchase Intent	
3B	Collectible (sport cards)	H3	Purchase a digital collectible NBA card (Michael Jordan) with physical versions. Same conditions as Study 3A	Three-factor between-subjects dual-format purchase eligible vs. dual-format purchase ineligible (vs. digital-only reference)	Psychological Ownership	Purchase Intent	Resale Value
4	Accessory (avatar)	H4	Purchase a digital backpack for their avatar available in two main conditions: dual-format where the UDA was launched before the physical version (dual-format original) and after (dual-format copy). A digital-only condition was included for reference	Three-factor between-subjects dual-format UDA original vs. dual-format UDA copy (vs. digital-only reference)	Psychological Ownership	Purchase Intent	

Key: UDA - Unique Digital Asset available in the metaverse.

the prominence of art as a commonly traded asset within the metaverse, it was selected as the contextual focus for this study. Some experts claim that virtual worlds are “revolutionizing the art world”.¹ As we also do in subsequent studies, the UDA was operationalized as an NFT, which is also typical for the metaverse (Deakin, 2022).

2.1.1. Stimuli, procedure, and sample

A vignette scenario-based experiment was designed. The survey started with a brief description of NFTs, scripted to ensure that participants had sufficient knowledge to answer subsequent questions (this description was included in all remaining studies). Participants were then invited to imagine inhabiting a fictional virtual world called Virtual Earth, where they are browsing an art marketplace. The marketplace has digital artwork available to purchase—participants were told that they are looking for something to decorate their virtual home. A digital artwork (i.e., NFT) generated through a popular AI image generator (DALL·E) was then shown to them. Participants were told that ‘a number’ of units (i.e., copies) are available to own but the exact amount was not disclosed in order to retain the authenticity of the experience, which is more typical of retail shopping settings.

In the UDA_{dual-format} condition, participants were told that the artwork was available in both digital form *and* that physical (printed) versions were also available and could be bought by other consumers in the real world. In the UDA_{digital-only} condition, the artwork was available in digital format only—no physical version exists. The detailed vignettes for all studies are provided in Web Appendix A. It is worth noting that we never referred to the conditions using the terminology presented in the manuscript (i.e., unique digital assets); instead, we described the product’s availability based on its characteristics (e.g., NFT).

Next, participants were exposed to the artwork, and responses to an attention and manipulation check question were collected. The attention check read as follows: ‘This NFT artwork is available only as a digital asset, and there is no corresponding physical counterpart in the real world/is available as a digital asset but with identical physical printed version in the real world’. The manipulation check involved a 7-point single-item Likert-type scale question asking whether ‘this NFT artwork only exists in the form of a digital asset, and there is no corresponding physical printed version in the market’ (1 = strongly disagree to 7 = strongly agree). Next,

¹ https://insights.masterworks.com/nft-metaverse/metaverse-art/#What_Does_Metaverse_Mean_for_the_Fine_Art_World_Key_Benefits

Table 2
ANOVA results for all studies.

	Participants	Variable	Variable Type	Condition and Coding	Number	Mean	SD	F	P value	η^2		
Study 1	141 (88 female) Mage=31.41, SDage=8.62	Purchase Intent	Dependent Variable	Digital-only=0	72	5.14	1.43	12.345	.0006	.082		
				Dual-format=1	69	4.35	1.43					
		Willingness to Pay	Dependent Variable	Digital-only=0	72	2.20	.40	4.417	.0374	.031		
				Dual-format=1	69	2.07	.31					
Study 2A	235 (160 female) Mage=31.33, SDage=7.45	Purchase Intent	Dependent Variable	Digital-only=0	119	5.99	.98	5.656	.0182	.024		
				Dual-format=1	116	5.67	1.08					
		Psychological Ownership	Mediator Variable	Digital-only=0	119	6.11	.82	6.548	.0111	.027		
				Dual-format=1	116	5.83	.84					
Study 2B	236 (168 female) Mage=32.01, SDage=7.44	Purchase Intent	Dependent Variable	Digital-only=0	119	5.57	1.09	4.147	.0428	.017		
				Dual-format=1	117	5.22	1.48					
				Psychological Ownership	Mediator Variable	Digital-only=0	119	5.82	.99	8.391	.0041	.035
				Dual-format=1	117	5.39	1.26					
		Format Uniqueness	Mediator Variable	Digital-only=0	119	6.13	.79	47.302	<0.0001	.168		
				Dual-format=1	117	5.12	1.40					
Study 3A	279 (178 female) Mage=30.95, SDage=8.74	Purchase Intent	Dependent Variable	Digital-only=1	98	5.08	1.29	4.640	.0104	.033		
				Dual-eligible=2	100	4.56	1.51					
				Dual-ineligible=3	81	5.10	1.36					
				Psychological Ownership	Mediator Variable	Digital-only=1	98	5.61	1.23	6.143	.0025	.043
				Dual-eligible=2	100	4.96	1.51					
				Dual-ineligible=3	81	5.36	1.19					
Study 3B	355 (all male) Mage=31.62, SDage=9.47	Purchase Intent	Dependent Variable	Digital-only=1	130	5.62	1.12	.443	.6424	.003		
				Dual-eligible=2	116	5.52	1.25					
				Dual-ineligible=3	109	5.65	1.03					
				Resale Value	Dependent Variable	Digital-only=1	130	6.59	.78	.910	.4033	.005
				Dual-eligible=2	116	6.55	.86					
				Dual-ineligible=3	109	6.70	1.04					
		Psychological Ownership	Mediator Variable	Digital-only=1	130	6.05	.65	2.962	.0530	.017		
				Dual-eligible=2	116	5.84	.91					
				Dual-ineligible=3	109	6.06	.75					
Study 4	277 (175 female) Mage=30.31, SDage=8.67	Purchase Intent	Dependent Variable	Digital-only=1	98	5.64	.96	16.721	<0.0001	.110		
				Digital-original=2	92	5.10	1.22					
				Digital-copy=3	87	4.68	1.23					
				Psychological Ownership	Mediator Variable	Digital-only=1	98	5.98	.81	13.246	<0.0001	.088
				Digital-original=2	92	5.66	.85					
				Digital-copy=3	87	5.23	1.28					

participants recorded their purchase intent towards the UDA (NFT artwork), using a single-item (i.e., how likely are you to buy this NFT artwork?) measured on a 7-point scale anchored as “1 = very unlikely” and “7 = very likely”, which was adapted from [Barton et al. \(2022\)](#). Willingness-to-pay (WTP) was captured using an auction-framed question which was adapted from [Morewedge et al. \(2021\)](#): if this NFT artwork is to be sold at auction, the starting price will be 50 RMB. Please enter the maximum amount you would be willing to bid. Demographic data (i.e., Gender and Age) and other relevant control variables were measured to ensure the comparability of sample structure across conditions (Chen et al. 2020). To this end, we included one-item measures for product interest (i.e., how interested are you in artwork?) using a 7-point scale (1 = not interested at all to 7 = very interested); knowledge of UDAs (i.e., how would you evaluate your current knowledge of digital assets supported by NFTs?) also reported on a 7-point scale (1 = very little to 7 = very much); and virtual avatar/world experience (i.e., have you ever designed a virtual avatar/inhabited a virtual world platform), as binary variables (Yes/No). Following the comparability testing protocol from [Chen et al. \(2020\)](#) no differences across conditions were found (p 's > 0.05) for all these variables in this study, nor subsequent ones (see Appendix A for comparability testing results for all studies).

A sample of 150 adults residing in the People's Republic of China were recruited using Credamo, a Chinese platform providing paid survey panels. Credamo is a popular and credible method of data collection commonly utilized in academic research (see [Huang & Sengupta, 2020](#); [Li et al., 2023](#)). It is used in all further studies. As such, the survey questionnaire was back-translated from English into Chinese ([Behr & Shishido, 2016](#)). Two participants failed an attention check and seven were identified as providing responses of unsatisfactory quality, yielding a final sample of 141 participants (62.41 % female, $M_{age} = 31.41$ years, $SD = 8.62$). Specific details of those excluded cases against an exclusion protocol deployed in all studies is available in Web Appendix B.

2.1.2. Results and discussion

A correlation matrix for displaying focal variables in each study is provided in Appendix B. A One-way Analysis of Variance (ANOVA) confirmed that the format availability manipulation was successful (see Appendix C for the results of each manipulation check in the study sequence). A second ANOVA showed that the dual-format UDA led to a lower score for purchase intent ($M_{\text{dual-format}} = 4.35$, $SD = 1.43$) compared to when the UDA was available as a digital-only version ($M_{\text{digital-only}} = 5.14$, $SD = 1.43$; $F(1, 139) = 12.35$, $p < 0.001$, $\eta^2 = 0.08$). We then performed the same test on the willingness-to-pay estimate. However, the distribution around the mean ($M_{\text{digital-only}} = 247.31$ yuan, $SD = 326.00$ vs. $M_{\text{dual-format}} = 216.96$ yuan, $SD = 584.56$) was highly, and positively, skewed (skew = 3.85). To enhance the predictability of the manipulation whilst making it eligible for parametric testing, the dependent variable was subjected to a logarithmic transformation (log10) (Wilcox, 2010). The ANOVA with the transformed variable revealed a pattern consistent with purchase intent. Specifically, participants in the UDA_{digital-only} condition reported a greater willingness to pay ($M_{\text{digital-only}} = 2.20$, $SD = 0.40$) than those in the UDA_{dual-format} condition ($M_{\text{dual-format}} = 2.07$, $SD = 0.31$; $F(1, 139) = 4.42$, $p = .04$, $\eta^2 = 0.03$).² Illustrative results are shown in graphical form in Fig. 2.

In summary, these results provide support for H1. Compared to the digital-only condition, when a physical version of the UDA exists in the real world, purchase evaluations are lower. This finding therefore provides preliminary evidence for the ‘cross-format dilution effect.’ In the next study, we examine ‘why’ this may be the case by focusing on psychological ownership as the mediating link in the chain.

2.2. Study 2A: the mediating role of psychological ownership

To test H2, a between-subjects design was initiated to establish the impact of format availability (UDA_{dual-format} vs. UDA_{digital-only}) on purchase intent, via psychological ownership. The UDA was designed as a pair of digital sneakers that could be worn by the user’s digital avatar.

2.2.1. Stimuli, procedure, and sample

A new online vignette scenario-based experiment encouraged participants to imagine inhabiting a virtual world where they engaged in a virtual shopping trip to buy clothing for their avatar. In visiting a virtual store owned by an unspecified but popular sports clothing brand, participants were told they found a pair of sneakers. In the UDA_{dual-format} condition, they were informed that 25 (NFT) copies of the digital sneakers existed for 100 RMB (approximately USD 14), with 25 physical pairs also available in the real world—as before, they could not personally buy these. In the UDA_{digital-only} condition, 50 NFT copies existed at a price of 100 RMB (see Web Appendix A for the full scenario). The price of 100 RMB reflects the average price of NFTs available in the most popular digital assets trading platform in China.³

Following the vignette, the same attention check, manipulation check, and measures for purchase intent and controls were presented as Study 1 (amended for the context of sneakers). In addition, a three-item measure for anticipated *psychological ownership* (e.g., I have a very high degree of personal ownership towards this pair of sneakers) was adapted from Morewedge et al. (2021) and anchored on a 7-point scale (1 = strongly disagree to 7 = strongly agree), $\alpha = 0.77$. The full measure is provided in Appendix D.

Two hundred and fifty Chinese adults were recruited using the same procedure as in Study 1. After excluding 11 participants who failed the attention check and four who provided unsatisfactory quality responses, the final sample consisted of 235 participants (68 % female; $M_{\text{age}} = 31.33$ years, $SD = 7.45$).

2.2.2. Results and discussion

The format availability manipulation was successful (see Appendix C). Separate ANOVAs showed that the dual-format approach again resulted in lower levels of purchase intent ($M_{\text{digital-only}} = 5.99$, $SD = 0.98$ vs. $M_{\text{dual-format}} = 5.67$, $SD = 1.08$; $F(1, 233) = 5.66$, $p = .02$, $\eta^2 = 0.02$), but also psychological ownership ($M_{\text{digital-only}} = 6.11$, $SD = 0.82$ vs. $M_{\text{dual-format}} = 5.83$, $SD = 0.84$; $F(1, 233) = 6.55$, $p = .01$, $\eta^2 = 0.03$) compared to the digital-only condition. Illustrative results are shown in graphical form in Fig. 3.

Using Model 4 (5000 bootstraps) in the IBM SPSS PROCESS MACRO (Hayes 2017), we assessed the indirect effect of format availability on the dependent variable (purchase intent), mediated by psychological ownership. The dual-format (vs. digital-only) led to lower feelings of psychological ownership ($b_{\text{UDA}_{\text{digital-only}} \rightarrow \text{psychological ownership}} = -0.28$, $p = .01$), which itself had a negative effect on purchase intent ($b_{\text{psychological ownership} \rightarrow \text{purchase intent}} = 0.49$, $p < 0.001$). The combined paths demonstrated a significant, and negative, indirect effect through psychological ownership ($b_{\text{psychological ownership}} = -0.13$, 95 % CI: -0.2711 to -0.0399). Table 3.1 provides mediation estimates for this and each subsequent study.

Study 2A supports H2. Specifically, we show that, when UDAs are available in a dual-format, with a physical version, purchase evaluations reduce because consumers feel a lower level of psychological ownership towards the UDA (as compared to a digital-only format). In theorizing this dilution, we suggested that the inclusion of a physical counterpart leads the UDA to be evaluated as less unique or exclusive (i.e., format uniqueness), creating a reduced sense of pride in ownership. In Study 2B we validate this logic. Moreover, we acknowledge that, whilst having more copies available for the digital-only condition (i.e., 50 vs. 25) provides a very conservative condition of our logic, it may also be depreciating the scale of the effect. As such, we equalize the copies available in the next study.

² Refer to Table 2 for detailed ANOVA results for all studies.

³ <https://jingtanbusiness.antgroup.com/index>

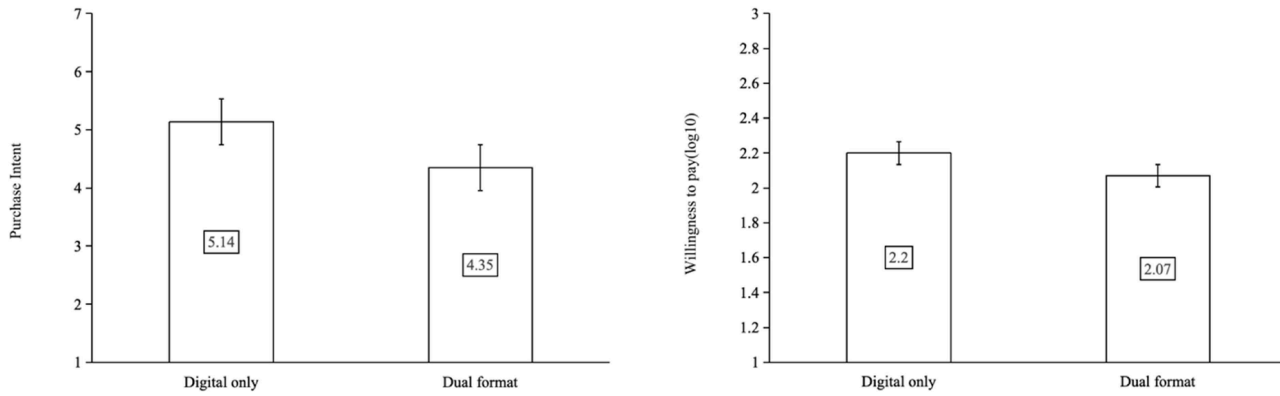


Fig. 2. The effects of UDA format availability on purchase evaluations in Study 1.

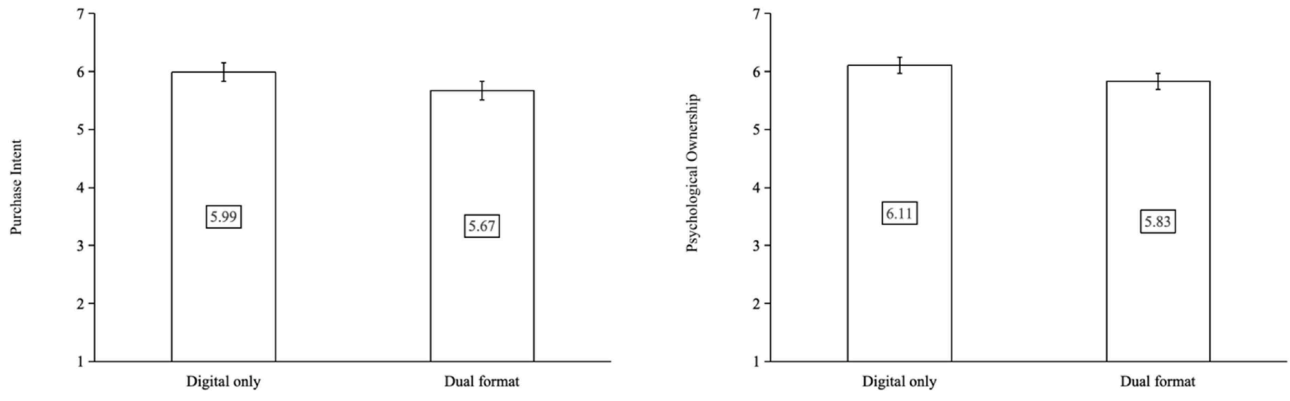


Fig. 3. The effects of physical product accessibility on purchase intent and psychological ownership in Study 2A.

Table 3.1
Mediation – all studies.

	Model 1 (X → M) M: Psychological Ownership			Model 2 (X,M→ Y) DV1: Purchase Intent DV2: Resale Value		
	B	s.e.	p	b	s.e.	p
Study 2A (DV1)	F(1233) = 6.548, p = 0.0111, R-sq=0.027			Ind Eff = -0.134 CI (-0.270 - -0.033)		
Format Availability (digital-only vs. dual-format)	-0.276	.108	.0111	F (2232) = 5.656, p = 0.0182, R-sq=0.024		
Psychological Ownership				-0.319	.134	.0182
Study 2B (DV1)	F(1234) = 8.391, p = 0.0041, R-sq=0.035			Ind Eff = -0.342 CI (-0.614 - -0.110)		
Format Availability (digital-only vs. dual-format)	-0.427	.147	.0041	F (2233) = 4.147, p = 0.0428, R-sq=0.017		
Psychological Ownership				-0.344	.169	.0428
Study 3A (DV1)	F(1196) = 11.181, p = 0.0010, R-sq=0.054			Ind Eff = -0.433 CI (-0.720 - -0.178)		
Format Availability (digital-only vs. dual-eligible)	-0.656	.196	.0010	F (2195) = 6.804, p = 0.0098, R-sq=0.0335		
Psychological Ownership				-0.522	.200	.0098
Study 3A (DV1)	F(1179) = 3.862, p = 0.0509, R-sq=0.145			Ind Eff = 0.287 CI (0.005 - 0.567)		
Format Availability (dual-eligible vs. dual-ineligible)	.405	.206	.5090	F (2178) = 6.22, p = 0.0135, R-sq=0.183		
Psychological Ownership				.539	.216	.0135
Study 3A (DV1)	F(1177) = 1.9, p = 0.1699, R-sq=0.01			Ind Eff = -0.08 CI (-0.208 - 0.027)		
Format Availability (digital-only vs. dual-ineligible)	-0.13	.091	.1699	F (2176) = 0.008, p = 0.9312, R-sq=0		
Psychological Ownership				.009	.099	.9312
Study 3B (DV1)	F(1244) = 4.174, p = 0.0421, R-sq=0.017			Ind Eff = -0.194 CI (-0.389 - -0.007)		
Format Availability (digital-only vs. dual-eligible)	-0.204	.100	.0421	F (2243) = 0.491, p = 0.4843, R-sq=0.002		
Psychological Ownership				-1.060	.151	.4843
Study 3B (DV1)	F(1223) = 3.95, p = 0.048, R-sq=0.017			Ind Eff = 0.193 CI (0.003 - 0.407)		
Format Availability (dual-eligible vs. dual-ineligible)	.222	.112	.0480	F (2222) = 0.763, p = 0.384, R-sq=0.003		
Psychological Ownership				.134	.154	.3840
Study 3B (DV1)	F(1237) = 0.04, p = 0.8415, R-sq=0.0002			Ind Eff = 0.007 CI (-0.068 - 0.086)		
Format Availability (digital-only vs. dual-ineligible)	.009	.045	.8415	F (2236) = 0.041, p = 0.8399, R-sq=0.0002		
Psychological Ownership				.014	.07	.8399
Study 3B (DV2)	F(1244) = 4.174, p = 0.0421, R-sq=0.017			Ind Eff = -0.027 CI (-0.089 - 0.123)		
Format Availability (digital-only vs. dual-eligible)	-0.204	.100	.0421	F (2243) = 0.128, p = 0.7213, R-sq=0.001		
Psychological Ownership				-0.038	.105	.7213
Study 3B (DV2)	F(1223) = 3.95, p = 0.048, R-sq=0.017			Ind Eff = 0.026 CI (-0.016 - 0.091)		
Format Availability (dual-eligible vs. dual-ineligible)	.222	.112	.0480	F (2222) = 1.476, p = 0.2257, R-sq=0.007		
Psychological Ownership				.155	.127	.2257
Study 3B (DV2)	F(1237) = 0.04, p = 0.8415, R-sq=0.0002			Ind Eff = 0.001 CI (-0.008 - 0.012)		
Format Availability (digital-only vs. dual-ineligible)	.009	.045	.8415	F (2236) = 0.983, p = 0.3226, R-sq=0.004		
Psychological Ownership				.059	.059	.3226
Study 4 (DV1)	F(1188) = 7.037, p = 0.0087, R-sq=0.036			Ind Eff = -0.217 CI (-0.397 - -0.057)		
Format Availability (digital-only vs. dual-original)	-0.320	.121	<0.0001	F (2187) = 11.798, p = 0.0007, R-sq=0.059		
Psychological Ownership				-0.545	.159	.0007
Study 4 (DV1)	F(1183) = 23.290, p < 0.0001, R-sq=0.113			Ind Eff = -0.191 CI (-0.310 - -0.090)		
Format Availability (digital-only vs. dual-copy)	-0.377	.078	<0.0001	F (2182) = 35.760, p < 0.0001, R-sq=0.164		
Psychological Ownership				-0.482	.081	<0.0001
Study 4 (DV1)	F(1177) = 7.173, p = 0.0081, R-sq=0.039			Ind Eff = -0.209 CI (-0.413 - -0.052)		
Format Availability (dual-original vs. dual-copy)	-0.433	.162	.0081	F (2176) = 5.219, p = 0.0235, R-sq=0.029		
Psychological Ownership				-0.420	.184	.0235
				.481	.078	<0.0001

Note – All mediation tests presented were undertaken through Hayes Model 4 with bootstrapping set to 4000 at 95 %.

2.3. Study 2B: replicating and extending the mediated process

The study design mirrored Study 2A with the addendum, that in the UDA_{digital-only} condition, 25 NFT sneakers were made available, which was consistent with the UDA_{dual-format} condition (25 digital + 25 physical): see Web Appendix A for the full scenario. The measures replicated Study 2A, but with two exceptions. First, to validate ‘why’ psychological ownership for the UDA had diminished under the dual-format condition, we included a separate measure for *format uniqueness*. If our theorizing is correct, not only will

psychological ownership decrease as a result of being part of a dual-format, but that this will happen because the UDA is seen as less unique and special. This required participants to record their perceptions of how *unique* the UDA felt *in light* of the format (i.e., digital-only vs. dual-format). We collected this using four items (i.e., unique, special, one of a kind, and exclusive) on a 7-point Likert-type scale (1 = Strongly disagree to 7 = Strongly agree, $\alpha = 0.92$), which was developed specifically for the study. The measure developed aligned nicely with an established measure originally offered by Franke and Schreier (2008). Two (pre-)studies including a qualitative exploration and quantitative validation informed the scale development. For comprehensiveness, both pre-studies are elaborated further in Web Appendix C.

We also chose to include an alternative measure of purchase intent. This had three items (e.g., I am likely to purchase the pair of sneakers), captured on a 7-point scale (1 = Strongly disagree to 7 = Strongly agree), and was amended from Berry et al. (2015), ($\alpha = 0.93$) (see Appendix D). A total of 236 usable responses were collected (71 % female, $M_{\text{age}} = 32.01$ years, $SD = 7.44$) representing the exclusion of 14 participants (two respondents who failed the attention check and 12 who provided unsatisfactory data quality).

2.3.1. Results and discussion

To assess the dimensionality and discriminance of the *format uniqueness*, *psychological ownership*, and *purchase intent* measures, we performed a confirmatory factor analysis (CFA). All diagnostic tests revealed satisfactory outcomes: reporting of this test is provided in Appendix E.

After confirming the manipulation had worked (see Appendix C), we established the pattern of results replicated those in Study 2A for purchase intent ($M_{\text{digital-only}} = 5.57$, $SD = 1.09$ vs. $M_{\text{dual-format}} = 5.22$, $SD = 1.48$; $F(1, 234) = 4.15$, $p = 0.04$, $\eta^2 = 0.02$) and psychological ownership ($M_{\text{digital-only}} = 5.82$, $SD = 0.99$ vs. $M_{\text{dual-format}} = 5.39$, $SD = 1.26$; $F(1, 234) = 8.39$, $p = .004$, $\eta^2 = 0.04$). As expected, *format uniqueness* was higher in the digital-only condition ($M_{\text{digital-only}} = 6.13$, $SD = 0.79$ vs. $M_{\text{dual-format}} = 5.12$, $SD = 1.40$; $F(1, 234) = 47.302$, $p < 0.001$, $\eta^2 = 0.17$). Illustrative results are shown in graphical form in Fig. 4. An assessment of mediation (Hayes Model 4) revealed that the dual-format (vs. digital-only) condition was associated with lower purchase intent via (reduced) psychological ownership (b psychological ownership = -0.34 , 95 % CI: -0.6135 to -0.1097) (see Table 3.1).

For completeness, we ran a serial mediation (Hayes Model 6) whereby the effect of UDA format availability on purchase intent was mediated in serial by format uniqueness (M1) and psychological ownership (M2). The results confirmed a significant serial mediation ($b = -0.40$, 95 % CI: -0.6362 to -0.2100), suggesting that the dual-format approach is perceived as less unique (vs. digital-only), which ultimately triggers the chain of dilution. The full results of this are provided in Table 3.2. For absolute clarity, we elected to re-run this mediation but this time reversing the order of mediators (format availability – psychological ownership – format uniqueness – purchase intent). This also yielded a significant indirect effect ($b = -0.07$, 95 % CI: -0.1526 to -0.0163). Nonetheless, we remain confident in the articulation of the original sequence (format availability - format uniqueness – psychological ownership – purchase intent) on the basis that stimulus attributes (e.g., format uniqueness) should always be cognitively processed in advance of triggering subjective ownership experiences (akin to the Stimulus-Organism-Response (SOR) framework, (Mehrabian & Russell, 1974; Kim et al., 2018). This notion is also supported by a stronger indirect effect ($b = -0.40$) vs. the reverse ($b = -0.07$).

Study 2B provides additional validation of the cross-format dilution effect via the psychological ownership that consumers feel towards the UDA when it is offered in different formats. We now examine the availability of the physical product in a dual-format offering in more detail.

2.4. Study 3A: eligibility for other consumers to purchase a physical product

In Study 3A, we turn attention to H3. A between-subjects scenario-based experiment was designed to test the concept of physical product *eligibility*. Specifically, we address the following question: what is the impact on UDA purchase evaluations when participants know that *other* people can own or use the physical product, or not (i.e., eligible versus ineligible)? The experimental manipulation was operationalized at three levels (UDA_{dual-eligible} vs. UDA_{dual-ineligible} vs. UDA_{digital-only}).⁴ Ostensibly, this reflected the UDA being available with a physical counterpart that could/could not be purchased by other consumers, as well as a digital-only version. Please note that we included the latter category to enhance the interpretation of the results. The UDA was a baseball cap to be worn by the user's metaverse avatar.

2.4.1. Stimuli, procedure, and sample

The scenario mirrored Study 2A. In the UDA_{dual-eligible} condition, participants were told that the NFT baseball cap was also available as a physical version, which would be sold at selected (physical) retail stores, reflecting *purchase eligibility*. In the UDA_{dual-ineligible} condition, the physical cap could be found at selected retail stores but for display purposes only since *it would not* be for sale (or use). Participants within the UDA_{digital-only} condition were informed that the baseball cap exists only in NFT form (as per prior studies). In all conditions, the cap was priced at 100RMB (approximately USD 14). The number of NFTs available was not specified. The checks and measures were also the same as Study 2A (amended for contexts). However, in addition, a nominal instructional check was included for participants presented with a dual-format which asked them to state *if* the physical cap was available for sale, or not. Participants were removed if they answered this check incorrectly. Ten participants failed the attention check, 26 responded incorrectly to the standardized nominal instructional check, and six provided unsatisfactory responses (following our quality protocol). A final sample of 279

⁴ Please note that a traditional 2 (eligibility) by 2 (format availability) design was not possible. The eligibility of others to purchase the physical products can only be considered in relation to dual-format offerings.

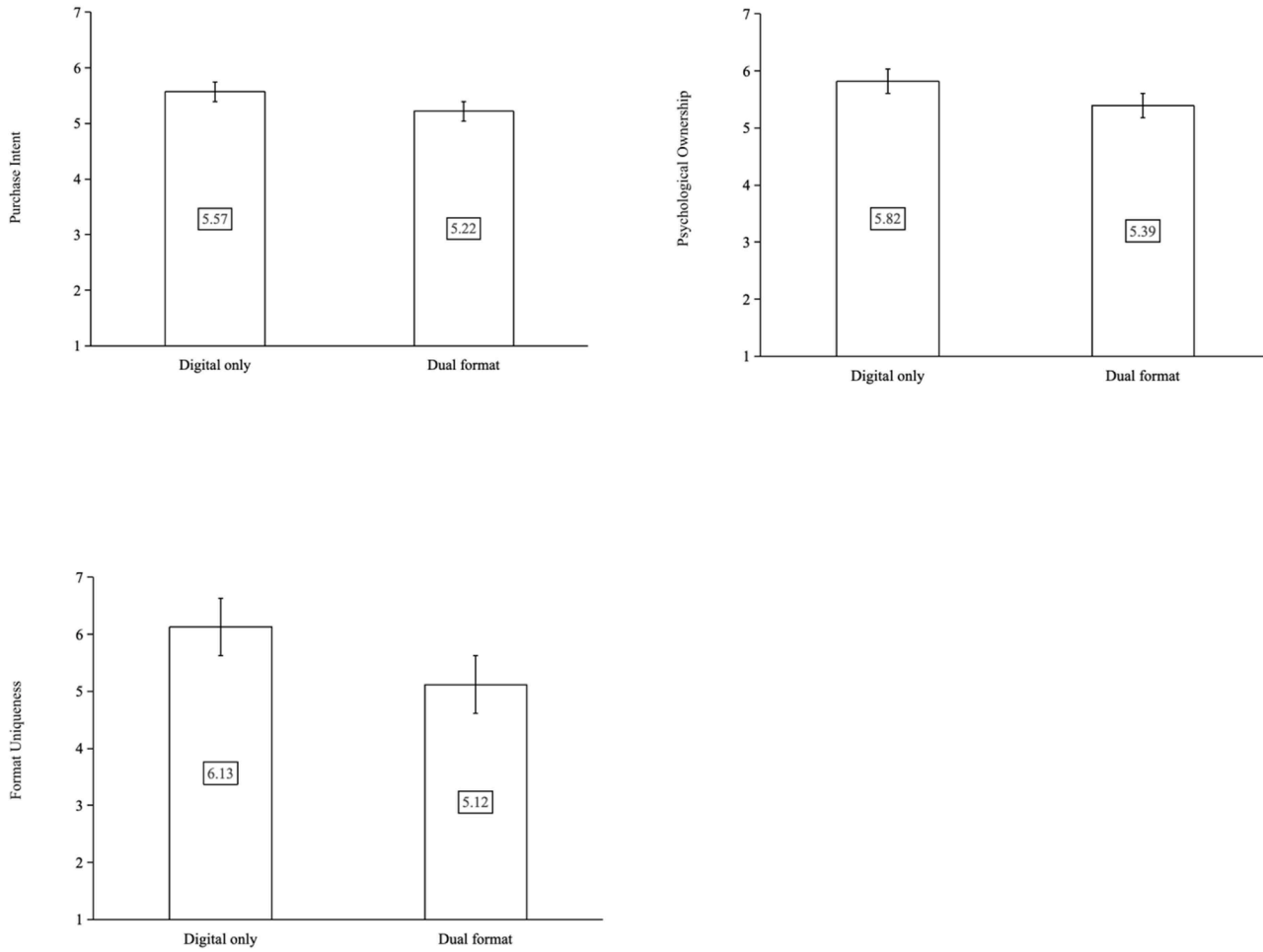


Fig. 4. The effects of UDA format availability on purchase intent, psychological ownership and format uniqueness in Study 2B.

Table 3.2
Serial mediation - Study 2B.

	Model 1 (X → M1) M1: Format uniqueness			Model 2 (X,M1 → M2) M2: Psychological ownership			Model 3 (X,M1,M2 → Y) DV: Purchase intent		
	<i>B</i>	<i>s.e.</i>	<i>P</i>	<i>b</i>	<i>s.e.</i>	<i>p</i>	<i>b</i>	<i>s.e.</i>	<i>p</i>
Study 2A									
							Ind Eff = -0.403 CI (-0.636 - -0.210)		
	F(1234) = 47.302, $p < .0001$, $R^2 = 0.168$			F(2233) = 114.176, $p < .0001$, $R^2 = 0.495$			F(3232) = 4.147, $p = 0.0428$, $R^2 = 0.0174$		
Format Availability (digital-only vs. dual-format)	-1.015	.148	<0.0001	.273	.117	.0206	.232	.129	.0721
Format Uniqueness				.691	.048	<0.0001	.325	.071	<0.0001
Psychological Ownership							.575	.071	<0.0001

were taken forward for analysis (63.8 % female, $M_{\text{age}} = 30.95$ years, $SD = 8.74$).

2.4.2. Results and discussion

The format availability manipulation was again successful (see Appendix C). The ANOVA revealed a significant difference in purchase intent across the three conditions ($F(2276) = 4.64$, $p = .01$, $\eta^2 = 0.03$), whereby pairwise comparisons showed purchase intent to be lower for the dual-format condition when the physical counterpart was *eligible* for others to own or use, when compared to the *ineligible* group ($M_{\text{dual-eligible}} = 4.56$, $SD = 1.51$ vs. $M_{\text{dual-ineligible}} = 5.10$, $SD = 1.36$; $F(1179) = 6.22$, $p = .01$, $\eta^2 = 0.03$). As expected, the purchase intent for the dual-eligible condition was also lower than that for the digital-only reference condition ($M_{\text{digital-only}} = 5.08$, $SD = 1.29$; $F(1196) = 6.80$, $p = .01$, $\eta^2 = 0.03$). It is worth noting that no significant difference in purchase intent was observed between the digital-only and dual-format condition without there being eligibility (*ineligible*) ($F(1177) = 0.007$, $p = .93$, $\eta^2 = 0.00$).

Concerning psychological ownership, we found a significant difference across all three groups ($F(2276) = 6.14$, $p = .00$, $\eta^2 = 0.04$). This pattern resembled the purchase intent variable; that is, psychological ownership was found to be lower in the dual-format condition for the *eligible* counterpart and higher for the *ineligible* version ($M_{\text{dual-eligible}} = 4.96$, $SD = 1.51$ vs. $M_{\text{dual-ineligible}} = 5.36$, $SD = 1.19$; $F(1, 179) = 3.86$, $p = .04$, $\eta^2 = 0.02$). Psychological ownership for the eligible condition was also lower than that for the digital-only reference condition ($M_{\text{digital-only}} = 5.61$, $SD = 1.23$; $F(1196) = 11.18$, $p < .001$, $\eta^2 = 0.05$). Illustrative results are shown in graphical form in Fig. 5. No significant difference in psychological ownership was found between the digital-only and ineligible dual format conditions ($F(1177) = 1.90$, $p = .17$, $\eta^2 = 0.01$).

Finally, we specified a model using Hayes Model 4. Since the manipulated variables comprised three levels, we contrast a coded dual-eligible condition against each of the other two conditions separately (Huang & Sengupta, 2020). In line with H3, the results revealed a significant indirect effect between the $UDA_{\text{dual-eligible}}$ (vs. $UDA_{\text{dual-ineligible}}$) on purchase intent (b psychological ownership = 0.29, 95 % CI: 0.0053 to 0.5671). Moreover, a significant mediation effect was obtained between the $UDA_{\text{dual-eligible}}$ (vs. $UDA_{\text{digital-only}}$) on purchase intent (b psychological ownership = -0.43, 95 % CI: -0.7200 to -0.1782). See Table 3.1 for the full results.

The findings of Study 3A are consistent with our theorization of the cross-format dilution effect, in the sense that it appears only to be present when a physical counterpart to the UDA is available (or eligible) for other consumers to own (or use). No dilution occurs in a dual-format context when the physical product does not fulfil this criterion (i.e., is ineligible for purchase by consumers).

2.5. Study 3B: purchase eligibility replication

In Study 3B, we attempted to replicate the results of Study 3A, using a different type of UDA. While all previous studies involve a UDA that can be used by the user's avatar within the metaverse (i.e., art to hang in their virtual home, or clothing for their avatar), here, we focus on a UDA that has investment potential. NFT basketball player cards are a common investment by collectors.⁵ Indeed, a LeBron James card sold for USD 387,600 in April 2021.⁶ NBA basketball cards have global appeal and are popular in Chinese markets.

2.5.1. Stimuli, procedure, and sample

A vignette was developed asking participants to imagine being interested in National Basketball Association (NBA) player cards. A total of 5000 limited-edition Michael Jordan cards were available for 300 RMB (approximately USD 42) each. This price point reflects similar market trends; for example, a rare Stephen Curry NFT card was recently priced at USD 38.⁷ In the $UDA_{\text{dual-eligible}}$ condition, participants were told that half of these limited-edition cards were being sold as digital NFTs (i.e., UDAs), with the other half as physical cards. In the $UDA_{\text{dual-ineligible}}$ condition, the physical half was being retained only for display in official NBA retail stores and would never be for sale or used by other consumers. For context, we again included a $UDA_{\text{digital-only}}$ condition, in which respondents were instructed that the cards only existed in digital form. The same measures and checks were included as per Study 3A (amended for NBA context). Given the investment focus, a measure for *resale value* was also included. The item read: "The current price of the digital

⁵ <https://www2.deloitte.com/cn/en/pages/technology-media-and-telecommunications/articles/pr-tmt-predictions-2022.html>

⁶ <https://nftnow.com/guides/nba-top-shot-guide/>

⁷ https://nft.paniniamerica.net/crypto-market-details/packcard-1587_290606_7861601_154?market=crypto

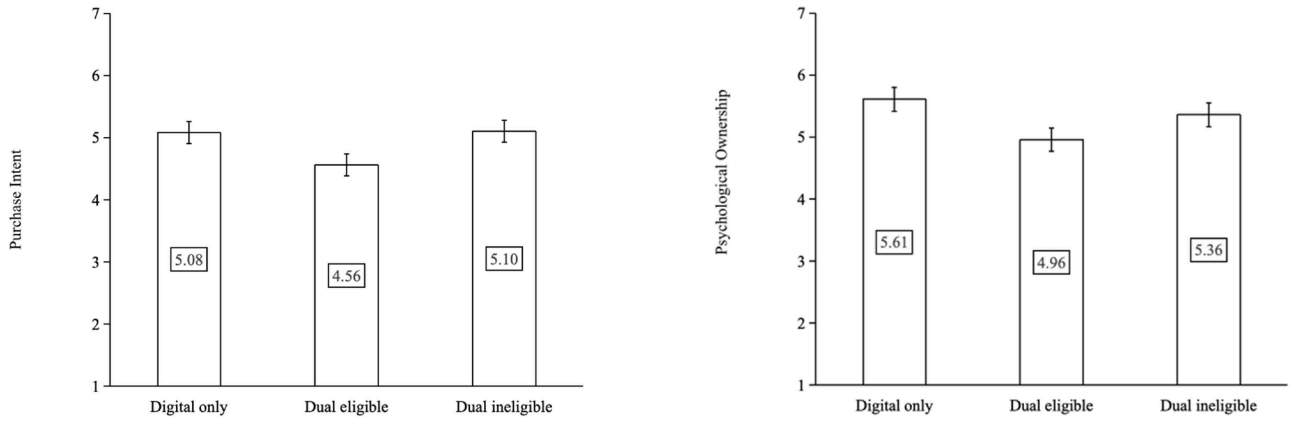


Fig. 5. The effects of UDA format availability on purchase intent and psychological ownership in Study 3A.

NFT NBA card is 300 RMB. If you were to sell your digital NFT NBA card in 12 months time, how much do you think it will be worth?" Answers are given in RMB. Other checks and measures were in keeping with Study 3A (amended for contexts). In addition to the pool of control variables used earlier in the study sequence, we captured attitudes towards Michael Jordan. Appendix D provides the wording of this.

We recruited males living in China. Basketball cards are mainly purchased by men—hence the single sex sample focus⁸. After data cleaning 40 participants were removed, leaving a final sample of 355 participants. Five participants were removed for failing attention checks, 29 for instruction check non-compliance, and six for unsatisfactory quality responses, yielding a final sample of 355 participants ($M_{\text{age}} = 31.62$ years, $SD = 9.47$).

2.5.2. Results and discussion

Once again, the format availability manipulation was successful (see Appendix C). In this scenario where the UDA has investment potential ANOVAs revealed no significant differences across availability format conditions for both purchase intent ($M_{\text{dual-eligible}} = 5.52$, $SD = 1.25$ vs. $M_{\text{dual-ineligible}} = 5.65$, $SD = 1.03$ vs. $M_{\text{digital-only}} = 5.62$, $SD = 1.12$; $F(2352) = 0.443$, $p = .64$, $\eta^2 = 0.003$) and resale value ($M_{\text{dual-eligible}} = 6.55$, $SD = 0.86$ vs. $M_{\text{dual-ineligible}} = 6.70$, $SD = 1.04$ vs. $M_{\text{digital-only}} = 6.59$, $SD = 0.78$; $F(2352) = 0.91$, $p = .40$, $\eta^2 = 0.005$).⁹ Albeit the case, a significant difference was found in psychological ownership across the three conditions ($F(2352) = 2.96$, $p = .05$, $\eta^2 = 0.02$). Specifically, pairwise comparisons revealed that the psychological ownership of the UDA with a physical counterpart eligible for purchase is lower than the UDA with a physical counterpart ineligible for purchase ($M_{\text{dual-eligible}} = 5.84$, $SD = 0.91$ vs. $M_{\text{dual-ineligible}} = 6.06$, $SD = 0.75$; $F(1223) = 3.96$, $p = .03$, $\eta^2 = 0.02$) and is also lower than the UDA without a physical counterpart ($M_{\text{digital-only}} = 6.05$, $SD = 0.65$; $F(1244) = 4.17$, $p = .04$, $\eta^2 = 0.02$). Again, as in Study 3A, no significant difference was found between the digital-only UDA and dual-format ineligible condition ($M_{\text{dual-ineligible}} = 6.06$, $SD = 0.75$ vs. $M_{\text{digital-only}} = 6.05$, $SD = 0.65$; $F(1237) = 0.04$, $p = .86$, $\eta^2 = 0.00$).

A mediation analysis confirmed a significant indirect effect between UDA_{dual-eligible} (vs. UDA_{dual-ineligible}) on purchase intent (b psychological ownership = 0.19, 95 % CI: 0.0029 to 0.4074). A further significant mediation was found between UDA_{dual-eligible} (vs. UDA_{digital-only}) and purchase intent (b psychological ownership = -0.19, 95 % CI: -0.3889 to -0.0066) (see Table 3.1). A further mediation was specified to resale value as the dependent variable. A borderline indirect effect was established between the UDA_{dual-eligible} and UDA_{dual-ineligible} conditions. Both the [a] and [b] paths were significant; however, the bootstrapped indirect path was only approaching significance as evidenced in the confidence intervals crossing the zero threshold (b psychological ownership = 0.03, 95 % CI: -0.0162 to 0.0911). Although these results tentatively suggest that resale value falls when a physical counterpart is eligible for purchase, we urge caution in interpreting and generalizing this result.

Overall, the findings provided further support for H3 (based on mean comparisons of psychological ownership and assessment of mediation on purchase intention). It is worth noting that in this context we established no significant direct effect of the three format availability conditions on purchase intention or resale value. Nonetheless, psychological ownership was lowest for the UDA with a physical counterpart that was eligible for purchase. Also, the mediation results tentatively (approaching statistical significance) suggest that the digital-only condition (vs. dual-ineligibility) was associated with a higher resale value through psychological ownership.

Through Studies 3A and 3B, we show that the cross-format dilution effect happens *only* when the physical product can be owned or used by other consumers, which supports the conceptualization that consumers actively devalue the UDA in a dual-format, not because a physical version exists, but because other consumers can own or use it. In this sense, dilution can be mitigated. Despite this, inconsistent direct effects on purchase intent suggest the potential for differences across personal use and investment contexts. In the final study, we look at another managerially relevant mitigation strategy; that is, the 'ordering' in which the UDA is launched. Specifically, we assess whether the UDA is available prior to, or after, the physical version.

2.6. Study 4: launch order of UDAs within a dual-format approach

A scenario-based between-subjects experiment was operationalized, manipulating the order in which the UDA was launched (i.e., made available to buy). The conditions reflected whether the UDA was launched first or second¹⁰; more specifically, before or after the physical version. As in 3A and 3B, these conditions were contrasted with the digital-only version which was included as a reference group. Consequently, format availability was practically operationalized with three levels (UDA_{dual-original} vs. UDA_{dual-copy} vs. UDA_{digital-only}).¹¹ We reverted to previous studies (i.e., Study 2A) in setting the scenario but changed the product to a backpack.

2.6.1. Stimuli, procedure, and sample

In the UDA_{dual-original} condition, the backpack existed in both digital (UDA) and physical form. Participants were advised that the UDA had been launched *first*. In the UDA_{dual-copy} condition, the UDA was released second, after the physical version. In the UDA_{digital-only} condition, the backpack only existed as a UDA (as per prior studies). The UDA backpack was priced at 100 RMB (approximately

⁸ <https://www.statista.com/statistics/1195938/china-gender-distribution-of-basketball-fans/>

⁹ Resale value was assessed by log transformation due to high skewness (17.89).

¹⁰ We use the notation 'original' (first) versus 'copy' (second) to reflect the ordering by which the UDA is released.

¹¹ Please note that a traditional 2 (launch order) by 2 (availability format) design was not possible as development can only be considered related to dual-format offerings.

USD 14) in all conditions. The number of items (copies) available to be bought was unspecified. All measures were the same as before (i.e., Study 2A). A nominal instructional check aimed to clarify which backpack participants were told was released first, whereby respondents were removed if they answered wrongly. Twenty-three participants were excluded for failing the attention check, five for an incorrect nominal instruction check, and 13 for providing substandard responses, resulting in a final sample of 277 participants (63.1 % female, $M_{age} = 30.31$ years, $SD = 8.67$).

2.6.2. Results and discussion

The manipulation check for format availability was confirmed (see Appendix C). An ANOVA showed a significant difference across the three conditions for purchase intent ($F(2, 274) = 16.72, p < .001, \eta^2 = 0.11$). Pairwise comparisons demonstrate that for the dual-format condition whereby the UDA was released first (i.e., the original), purchase intent was significantly higher than when it was released second (i.e., the copy) ($M_{dual-original} = 5.10, SD = 1.22$, vs. $M_{dual-copy} = 4.68, SD = 1.23, F(1177) = 5.22, p = 0.02, \eta^2 = 0.54$). Nonetheless, the digital-only version was perceived as more purchasable than both dual-format offerings ($M_{digital-only} = 5.64, SD = 0.96$, vs. $M_{dual-original} = 5.10, SD = 1.22; F(1, 188) = 11.80, p < 0.001, \eta^2 = 0.55$, and $M_{dual-copy} = 4.68, SD = 1.23; F(1, 183) = 35.76, p < 0.001, \eta^2 = 0.60$).

A further ANOVA showed a significant difference in psychological ownership across conditions ($F(2, 274) = 13.25, p < .001, \eta^2 = 0.09$). Pairwise comparisons outlined the same pattern as with purchase intent above. Specifically, psychological ownership was higher in the original vs. the copy condition ($M_{dual-original} = 5.66, SD = 0.85$ vs. $M_{dual-copy} = 5.23, SD = 1.28; F(1, 177) = 7.17, p = .01, \eta^2 = 0.04$). Thus, H4 is supported. However, both dual-format conditions received lower psychological ownership than the digital-only condition ($M_{digital-only} = 5.98, SD = 0.81$ vs. $M_{dual-original} = 5.66, SD = 0.85; F(1, 188) = 7.04, p = .01, \eta^2 = 0.04$, and vs. $M_{dual-copy} = 5.23, SD = 1.28, F(1, 183) = 23.29, p < .001, \eta^2 = 0.11$). Illustrative results are shown in graphical form in Fig. 6.

As before, we specified PROCESS models using Model 4 of the Hayes Macro and UDA format availability as the independent variable. This revealed a significant negative indirect effect on purchase intent, when the UDA is released second vs. first (b psychological ownership = -0.21 , 95 % CI: -0.4015 to -0.0516). A further mediation test revealed a significant negative indirect effect for the digital-original when compared to the digital-only condition (b psychological ownership = -0.22 , 95 % CI: -0.3971 to -0.0573). Table 3.1 provides these results in full.

The study establishes a critical and practical mitigating tool to assess the prospect of a cross-format dilution effect. The findings suggest that, when the UDA is launched first (as the original product) in a dual-format scenario, consumers experience psychological ownership to a degree higher than when the UDA is launched after (as the copy of a physical product). Even when the UDA is an original within a dual-format offering, it is still associated with less psychological ownership compared to when no physical counterpart exists (i.e., digital-only). From a managerial perspective, the optimal ordering combination allowing firms to release products as both UDAs and physical products, limiting diluting interest in the former, is when the UDA is launched first. We elaborate on this and other findings in the general discussion.

3. General discussion

The metaverse is widely viewed as a frontier for new revenue streams, particularly through the sale of unique digital assets (UDAs)—such as virtual art, apparel, and collectible items.

However, little is known about how brands and retailers can take advantage of this opportunity, nor how they can drive purchase evaluations and uptake amongst consumers. Through a series of six scenario-based experiments using a host of assets typically bought and sold by retailers in the metaverse (e.g. digital sneakers, player cards, digital art), we determine that purchase evaluations (e.g. purchase intent) are influenced by the format in which a digital asset is made available. Whilst format availability doesn't materially impact the UDA itself, we establish that the mere existence of a physical version works to dilute purchase evaluations by reducing anticipated psychological ownership. We coin this a *cross-format dilution effect*.

We first evidence this dilution effect in Study 1 (supporting H1). In Studies 2A/B we show this as a process mediated by psychological ownership and underpinned by degraded format uniqueness. In other words, the existence of a physical counterpart makes consumers evaluate the UDA format as less unique, associating lower levels of ownership to it, resulting in reduced purchase evaluations. We then turn our attention to managerially relevant mitigating factors of the cross-format dilution effect, finding: first, that it is mitigated when consumers are unable to purchase the physical product (e.g. it is for display purposes only) within a dual-format offering (supporting H3). Second, dilution is lessened if the UDA is the first (i.e., 'original') product launched to market before a physical one (supporting H4).

3.1. Implications for theory

Our research makes three contributions to knowledge. First, there has been a significant swelling of interest in the metaverse (see Yoo et al., 2023), and digital products more generally (see e.g., Watkins et al., 2015; Nadini et al., 2021; Varadarajan et al., 2022). Nonetheless, no research to the best of our knowledge has examined the practicalities of *how* brands and retailers *can* and *should* make UDAs available within the marketplace. We address this gap (see calls from Yang, 2024; Yoo et al., 2023).

Our research provides compelling evidence that *if* the development of unique UDAs within the metaverse is a priority for brands and retailers, marked restraint should be exercised by managers in the development and release of physical versions at the same time; indeed, the mere existence of a physical version open to purchase by others, works to devalue the UDA. This naturally has implications for how product portfolios are managed. For many brands, taking tentative steps into the metaverse often means simply extending

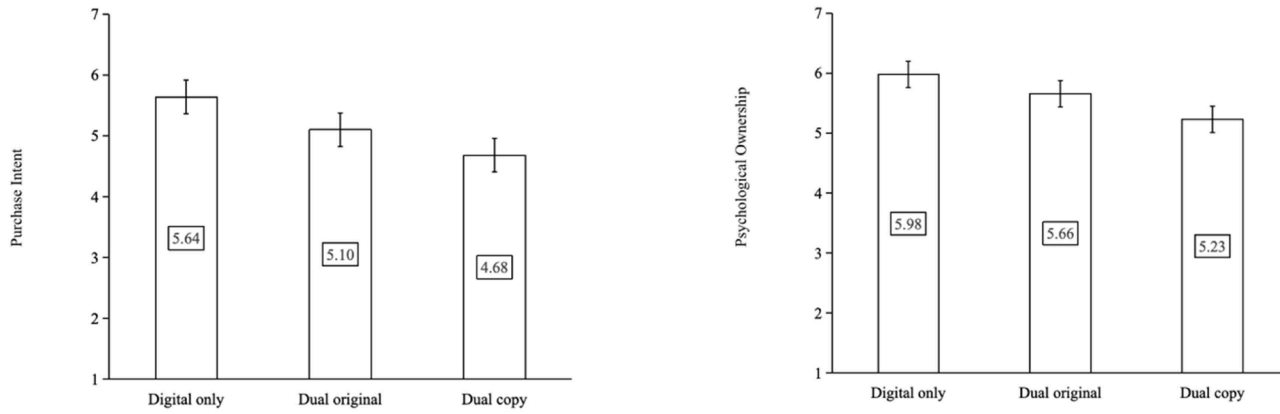


Fig. 6. The effects of UDA launch order on purchase intent and psychological ownership in Study 4.

existing product lines from the physical world into the virtual (Sundararajan, 2022). Our research suggests that this approach will result in limited success of the UDA as it will always be undermined by its physical counterpart. For others, UDAs may be a central focus (what Colicev, 2023 refers to as a standalone asset). In this case, the true impact of the UDA is realised by following our research findings: either offer a digital-only asset or, if a physical version is also to be released consider deploying mitigating factors identified in this research.

Whilst we provide empirical evidence for a *cross-format dilution effect*, the research stops short of being able to establish whether a digital-only approach is more financially viable. An interesting avenue for further research would be to establish if a digital-only (versus dual-format) strategy actually translates into stronger financial performance overall. Put differently, is cross-format dilution a major problem or a minor irritation?

Second, we show that cross-format dilution manifests through (lower) psychological ownership. Previous research has confirmed that anticipation of ownership plays a pivotal role in determining consumer outcomes in a range of a settings (e.g. Fritze et al., 2020; Carrozzini et al., 2019; Hulland et al., 2015). We expand on this stream of research. Critically, the findings demonstrate that when a dual-format approach is used, feelings of psychological ownership diminish. The corresponding argument stems from work showing that physical products have qualities (tactility, reliability, etc.) that are valued more highly than digital counterparts (Atasoy & Morewedge, 2018). Since *other* consumers can potentially own physical versions of the UDA, consumers feel lower (diluted) psychological ownership to the digital equivalent because it appears as less *unique* and special to them. In this sense, the research extends the work of Atasoy and Morewedge (2018) to provide an understanding of alternate contexts where digital and physical products co-exist as opposed to being simple alternatives of one another. Underlying this process is evaluation of format uniqueness, which reflects a key judgment consumers make when determining the perceived specialness of their purchase.

When reflecting on this contribution, it is important to recognize the scenario established in our studies which focuses on brands making a UDA obtainable to consumers without a physical version being overtly available. This follows the assumption that a brand has taken the approach of seeing UDAs as a potential standalone asset within their product portfolio. This assertion is central to the explanation of dilution. We acknowledge, however, that current UDA marketplace activity often lends itself to porting physical items into the virtual world making the UDA and physical items available simultaneously. Fashion brands regularly convert existing lines (i. e., physical products) into digital assets making them available to the *same* customer as part of a *bundle*, and at the same time (Colicev, 2023). We speculate that when *bundling*, because consumers can own both types of assets, dilution could *also* be undermined. However, further research would need to confirm this. It is also important to note that UDAs in the metaverse are different to traditional digital products (Watkins et al., 2016). Whilst we establish that physical products embody characteristics that outweigh their digital equivalent (Atasoy & Morewedge, 2018), which we use to justify the effects in the current context, a definite question mark remains over whether this will be maintained into the future as customer tastes and norms develop. Yang (2024) suggested that the metaverse could change the value of digital possessions by offering consumers the ability to intimately interact with digital goods in ways more akin to physical items. Therefore, the dominance of physical products may switch. A current example might relate to real-world items that have faster perishability rates (e.g. a bunch of flowers as a gift), meaning that the digital equivalent is seen as superior due to its ownership status and longevity. Again, further research would be needed to establish this and other categories where the pattern of results have the potential to be different.

Third, we respond to Yoo et al.'s (2023) call for scholars to explore how practitioners can attract customers to purchase UDAs by providing a theoretically grounded and actionable understanding of 'when' UDAs are evaluated most favorably. We present this below.

3.2. Implications for practice

To re-iterate, the most conclusive finding from this research is that marketers should be cautious about launching a new UDA in the metaverse alongside physical counterparts. However from a practical perspective, we also establish that this warning is caveated. Abandoning physical counterparts entirely need not be the only option, particularly when the UDA plays a central role in the broader strategy and there is a preference for cross-format modality. In developing this paper's third contribution, we outline two approaches to effectively mitigate dilution. For instance, in situations where a physical product will not be made available for purchase to other consumers (we call this eligibility), psychological ownership levels were found to be comparable to digital-only formats. This finding not only (further) supports the dilution thesis but offers a practical playbook for retailers to use. In addition, launching a UDA ahead of a physical version appears to have a similar effect. Primacy has been found as a positive antecedent of psychological ownership in the past (Morewedge et al., 2021) and we speculate this carries a lay-association as being "the original" product, ultimately boosting perceptions of uniqueness.

3.3. Limitations and future work

While our research provides robust insights into how format availability affects consumer evaluations of unique digital assets (UDAs), it also presents several limitations that suggest fruitful avenues for future research.

First, although we investigated the cross-format dilution effect across various product types—such as fashion, collectibles, and art—we did not explicitly compare these categories. Future research should systematically examine whether specific product characteristics (e.g., hedonic vs. utilitarian attributes, brand prestige etc.) moderate the observed dilution effects, providing more tailored insights across product categories.

Second, our findings primarily support indirect mediation through psychological ownership, yet alternative mechanisms could also explain the dilution effect. For instance, digital-only UDAs might strengthen consumers' feelings of community belonging or signal

their technological sophistication, influencing purchase evaluations independently or alongside psychological ownership. Employing advanced analytical techniques, such as binary Bayesian mixture modeling (Dyachenko & Allenby, 2023), future studies could better disentangle these possible alternative mediators and reveal heterogeneous consumer responses.

Third, we explored contexts aligned with personal use (e.g., digital avatar apparel) and investment purposes (e.g., collectible NBA cards) but did not directly contrast these motivations. Given that our investment-focused study (Study 3B) indicated mediation effects without a significant direct effect on purchase intent, future research should explicitly test how distinct consumer motivations—self-expression versus financial gain—interact with product format availability. Understanding this dynamic could clarify the nuanced impact of motivations on outcomes such as purchase intent, resale value, and willingness to pay.

Fourth, our participant sample comprised exclusively Chinese consumers. Given the substantial variation in attitudes toward digital products and the metaverse across cultures, future research should replicate our studies across diverse international markets. Such cross-cultural comparisons are particularly relevant as UDA adoption rates and familiarity with digital ownership vary widely globally, potentially influencing the generalizability of our findings.

Finally, while we focused on practically relevant mitigation strategies—such as physical product eligibility (display-only versus purchasable) and launch order—future work could investigate consumer-level moderators. Traits like the consumer's need for uniqueness, identity-signaling strength, or engagement level in virtual environments might reveal which consumer segments are more sensitive to the cross-format dilution effect, thereby enhancing practical segmentation strategies for retailers to work with.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jretai.2025.04.010](https://doi.org/10.1016/j.jretai.2025.04.010).

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